SCIENCE

VOL. 89 FRIDAY, MAY 19, 1939 No. 2316

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

HISTORY IN THE ARCHIVES OF THE ROYAL SOCIETY[1]

By Sir WILLIAM BRAGG

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THE archives of the Royal Society are rich in materials that illustrate various aspects of the history of the last three centuries. They have, of course, a special character, since they refer almost entirely to the matters in which the society has concerned itself, grouped under the general title of "The Improvement of Natural Knowledge." But these matters have increased in importance with the passing years and are now a subject of the first concern of the whole world. The effect of science upon social relations and social conditions has become very great, and the gains are obvious. Yet science does not appear to be in all cases beneficent. It has become a matter of anxious consideration whether or no the increase in the knowledge of nature must necessarily bring evil as well as good. Is there a fault to be remedied, and if so where does the fault lie? These questions have roused a debate which is even now in progress, and some hard thinking is being given to them.

It is of some help, I think, to consider the steps by which the present position has been reached, and the Royal Society archives may be used to provide the necessary illustrations. For that reason I hope that you will find it of some interest if, with that object in view, I refer to some of the papers and letters which they contain.

A few "virtuosi," to use the contemporary phrase, who met for discussion and experiment in the middle years of the seventeenth century were weary of the miseries of the civil war, and were glad to turn their thoughts to the consideration of natural phenomena over which the passions of men had no influence. Experimental science had long tempted thoughtful minds, and now the first founders of the Royal Society threw

[1] Pilgrim Trust Lecture, delivered before the National Academy of Sciences, April 24, 1939.

themselves with thankful relief into a work which seemed to them to be both a pressing duty and an absorbing occupation. They were like boys let out of school rushing out into the surrounding world to explore brooks and hedges and anything that seemed interesting. When I take down the first volumes of the *Transactions* from their shelves or look through the early manuscripts at the Royal Society, I feel as if I was turning out schoolboys' pockets and finding the usual assortment of mixed oddities.

In its first efforts the society was mainly concerned with the collection of information. The leading fellows sent questionnaires to various parts of the world which in their demand for comprehensive detail would have done credit to any inquisitive department of a modern government. An admirable example is to be found in the series of questions drawn up by Lord Brouncker and Mr. Boyle and approved at one of the earliest meetings of the society; in which most appropriate suggestions were made as to what should be looked for on an ascent of Teneriffe. It shows no little knowledge and penetration to inquire whether a "filtre or siphon" would work as well at the top of the mountain as at sea level, whether a bell or watch or gun would give the same sound, a flame have the same appearance, whether a pendulum clock went at the same rate, whether birds of heavy flight would fly as well or better or worse, and so forth. It was quite apt to ask what alterations would be found in living creatures carried to the top, both before and after feeding, and "what the experimenters do find in themselves as to difficulty of breathing, faintness of spirits, inclination to vomit, giddiness, etc." On March 28, 1672, Lord Henry Howard presented the answers to a series of questions on Barbary, where a retainer of his had recently been traveling: a remarkably pictorial account of the country and its inhabitants. It was expected apparently that some trace of the arts and sciences were to be found there, no doubt because it was known that the Arabian races had handed on the knowledge of the old world to the new. But there was no learning at all. In particular "there were no chemists except Jews and Christian slaves that distilled brandy in jars." So too a good account is given of Hudson's Bay and its people by a Captain Guilliaume and a Mr. Bailes, who had recently voyaged there. Naturally most of the information related to navigation and trade, but it is interesting to find also an account of the Maneto or Supreme Power and of his priest the Pawaw. The early records contain many such questionnaires and replies thereto.

Robert Boyle was the center of a vast correspondence on scientific and other matters, and fortunately a large collection of his papers is possessed by the society. Many of these have been published in his well-known "Life and Works." Quite a number of them crossed the Atlantic, and you will not blame me if I choose some of them to illustrate what I have to say. They were in the main of the informative type on which such great value was set. Thus a certain P.S. writes from Virginia on August 29, 1688, describing humming birds, also wampum, roanoke and pook, which were forms of currency. The trade measurement of length was the primitive cubit. The climate of New England was a frequent topic; it was supposed to be changing for the better. Perhaps under improving conditions the settlers were less susceptible to its rigors.

The governor of Boston, Leverett, and the deputy governor, Symonds, with other of their fellow citizens write to Boyle in protest against charges of disloyalty to the King, anxiously rebutting accusations of neglecting the baptism of infants and so forth. In 1682, Hezekiah Usher begs the remittance for 21 years of the King's claim for one fifth of all minerals recovered, so that prospecting may be encouraged.

Boyle's correspondence was, as the last two extracts show, by no means confined to scientific matters. After all, the first founders of the society were either statesmen themselves or closely connected with statesmen and might well be supposed to be proper persons to be entrusted with important news. Thus Richard Wharton writes from Boston in 1676, warning Boyle that the French are working round the interior of the settlements towards Carolina and the South. In 1684 Randolph writes from New England of the possibility of drawing on the vast forests of Maine for supplies of masts and timbers for the Navy, and discusses methods of making pitch and resin which are a secret of the French. John Winthrop writes in the same strain, urging the Royal Society to approach the government on the matter: he explains that there are sawmills handy to rivers, houses and provisions for workmen who may be sent, that small ships up to 400 tons have already been built. The supply of timber for the Navy was one of the greatest anxieties of Great Britain, from the time of his correspondence until steel replaced wood. Dry rot was a terrible curse from which the navy suffered more than the merchantmen, because the latter were more often aired and open to inspection during the loading and unloading. A strange story of its ravages is told by Ramsbottom in the *Essex Naturalist,* Volume XXV. Among the incidents of that story is the probable failure of the *Speedwell* to accompany the *Mayflower* on acount of dry rot.

It is well known that Boyle was deeply interested in the conversion of the Indians and that the Society for the Propagation of the Gospel owes much to his initiative. In 1664 he receives a letter from John Endicott, of Boston, describing the progress of the mission. John Eliot, also of Boston, writes frequently, expressing deep gratitude, and hopes for further help.

His address to Boyle was always eloquent, as for example "To the Right Honorable Learned abundantly charitable and constantly noursing Father."

In modern times it is an honor and an honor only to be elected a correspondent of a learned society. But a correspondent of the Royal Society in its early days was expected to correspond. When Cotton Mather was advised that he had been elected a fellow he wrote in 1715 to his friend Richard Waller, the society's secretary—the letter is in the society's archives—saying that

> . . . the tendency [of the society] to Refine and Sweeten the minds of men, and reconcile them unto Just Regards for True Merits in one another, with an extirpation of that noxious clamour the party spirit, and finally how generously the more polite Literators of the world go on in it, with a decent contempt on the Banters of the Bruitish among the people, but the result of his consideration will be that it will be a greater honour to be taken into the list of your servants, than to be mixed with the great men of Achaia.
>
> One who is entirely of that opinion, having been so listed with you has been desirous to discharge his obligations by agreeable assiduities, and therefore besides what every year brings you from him as an addition of Curiosities to the rich and vast assessment you are preparing he has bestowed a few hours upon the Philosophical Religion which he now humbly tenders to your acceptance.

The "Curiosities" here referred to became a famous object of interest in London; the collection was known as the "Repository." It grew to so great a size that the society found it unmanageable, and handed it in 1782 to the British Museum, which had been founded a few years before in order, in the first place, to contain the collections bequeathed to the nation by Sir Hans Sloane. Sir Hans was president of the society from 1727 to 1741.

The "Banters of the Bruitish" must clearly refer to the scornful comments of many clever men who did not sympathize with the experimental study of the world, who resented the intrusion of the new knowledge and laughed at the apparent futility and irrelevance of its beginnings. If they did not foresee the magnitude of its consequences they were little more at fault than the experimenters themselves. How could intelligent men waste time on objects so small that they must be examined under the microscope? Or on the consideration of such intangible substances as the air? How could they give serious attention to the abnormalities and monstrosities that idle correspondents thrust upon them? And, of course, the society did at first give their time to many accounts that even then must have looked ridiculous to men of a serious and settled mind. There were, for example, reports of a calf that had its hair inside out, of a man who squinted only on alternate days, of another who could not see if his hair were suffered to grow more than an inch long. It must have been quaint hearing when Dr. Tyson, at a meeting of the society, declared that one of his teeth having been drawn at Oxford some years before had been replaced and had apparently taken root again, since it was still of use. In those early days of inquiry it was of course necessary to sift all information that came to hand, but it would certainly be difficult for the unscientific mind to see the point in all cases. Dean Swift was a violent critic of the society's doings. It will be remembered that in his stay in the island of Brobdingnag Gulliver had an encounter with two wasps nearly as big as himself. He slew them with his sword and cut out their stings, which he brought eventually to England and presented to the Royal Society for its "Repository." In the voyage to Laputa, Gulliver found men, corresponding obviously to the physiological members of the society, who did remarkable experiments on men and animals. It is curious that Swift's wild inventions, which were intended as caricatures, are not unlike some of the beneficent methods of modern healing. It would not be very difficult to carve out a claim for Swift to be in some respects a pioneer of medicine as it is practised to-day.

These oddities were, however, an insignificant part of the society's proceedings. Of far more importance among the society's early papers are such as deal with the pressing questions of the day. Navigation claimed much attention. I have already referred to the anxieties respecting a sufficient supply of masts for the Navy. Perhaps the Dutch and French were aware of those difficulties when, as Ramsbottom remarks, they were accustomed to fire high in a sea fight.

At the end of the seventeenth century ships were growing considerably in size, since now they must become accustomed to the crossing of the Atlantic. Many English ports were unable to provide water of sufficient depth at all states of the tide, and tide tables were urgently required. Their calculation required the cooperation of mathematicians and astronomers. The archives contain of course many communications relating to the foundation of the Royal Observatory at Greenwich.

Pepys, when he was president of the society, begged continually for information on any matter whatever that might assist him in his care for the Navy. Probably he was really disappointed when Sir William Petty's double-bottomed ship turned out so badly, though he had made his bet that it would. Petty, a very able man, had supposed that a ship resembling in form two ships lashed side by side would stand up to a cross wind better than a ship of ordinary design. The idea was that, of course, which is embodied in the outrigger of some Polynesian races. Again, there is an interesting note in the account of the *Proceedings* of July 28, 1686.

. . . it was remarked that sheathing with lead was the best expedient (for preserving ships from the worms) and found to be so by the experience of Sir Anthony Deane; but that the carpenters finding it against their profit opposed it by affirming that the iron of the pintles of the rudders of ships so sheathed were much more apt to be corroded by the sea water than those sheathed with wood which yet was a groundless supposition.

The carpenters had more reason than was supposed: we know now that electrolysis can be exceedingly troublesome.

So also the ventilation of coal mines was an urgent question, and is frequently referred to in the archives. It had become necessary to dig deeper than before. The accumulation of water became a serious hindrance and the many noxious damps were often fatal. Air pumps and water pumps are dealt with in numerous well-known papers by Boyle, Hooke, Papin and others. Sir Robert Moray wrote on the ventilation of mines in Belgium. There was much correspondence on the subject. Its general character may be illustrated by an extract from a letter which a certain Dr. Jessop of Yorkshire wrote to the society in 1675. Let me give it in its original form, which now sounds so quaint.

There are four sorts (of damp) common in these parts. The first is *Ordinary Sort* of which I need not say much being known everywhere: the external signs of its approach are the candles burning orbicular and the flames lessening by degrees until it quite extinguish; the internal, shortness of breath. I never heard of any great inconvenience which anyone suffered by it, who escaped swooning. Those that swoon away and escape an absolute suffocation are at their first recovery tormented with violent Convulsions, the pain whereof when they begin to recover their senses, causeth them to roar exceedingly. The ordinary remedy is to dig a hole in the earth and lay them on their bellies with their mouths in it: if that fail they tun[2] them full of good Ale: but if that fail they conclude them desperate.

These few extracts from the records of the society will serve, I hope, to convey an impression of the character of the society's activity in its early days, when first an organized attempt to collect knowledge by experiment and observation began to exercise its influence. At whatever point one picks up the story as it is told in these old records, one finds it full of interest, which lies not only in the subjects that are dealt with, but also in their relation to the activities of the time, and to the men themselves whose handwriting lies before one.

It is to be observed that these records are easily read by an educated man. Those who wrote them had in general no thoughts which the educated man could not follow, nor was it necessary to use terms which were not in ordinary use. Newton's "Principia" would, of course, be intelligible to a small number only, but in general the "virtuosi" spoke a common language. The days of specialization and division into separate societies had not begun. How great is the contrast with the publications of a modern learned society!

It is also to be observed that there is no strict reckoning of services rendered, and no calculated recompense. Men like Hooke and other immediate servants of the society were paid for their work as was necessary and right, though the amount was incommensurate with their deserts. But the labors of the enthusiastic fellows and of their correspondents in all parts of the world were given freely. Indeed the society had no money to pay with. It received no financial assistance from the government, and the fellows' subscriptions (which, by the way, the treasurer found it remarkably difficult to collect) covered only the necessary expenses of the meetings. When the society decided to print the "Principia" Dr. Halley himself provided the necessary funds. To this day, the fellows give without reward the services which their connection with the society entails. But I do not ask for any special commendation; the point is that such free service is common among learned societies, and is certainly a chief reason why they are held in respect.

The general intelligibility of the communications to the Royal Society persists for a long time. The calculations of the astronomers, the mathematicians, opticians and so forth appealed naturally to a limited number, but still we may suppose that fellows were able to understand the most part of that to which they listened. Perhaps it may be said, broadly, that the change begins when new terms must be invented to describe the increasing complexity of observations, and new units for quantitative description. Electricity and magnetism have been chiefly responsible; so that the experiments on frictional electricity which were so popular in the middle of the eighteenth century are especial objects of interest. The progress of the subject is illustrated in the society's archives by the many papers and letters of Watson, Franklin and others. Franklin's communications came by way of his friend Collinson, who gave them to Watson for presentation to the society. Watson was himself a keen student of frictional electricity; and it would seem that some of the important experiments were made by Franklin and himself independently. But Franklin was of course the greater man, and Watson gave him full praise: "Although there are in the work some few opinions in which I can not perfectly agree with him I think scarce anybody is better acquainted with the subject of electricity than himself." Franklin was advised by his friend Mitchell that the paper on the subject of the identity of the lightning flash with the sparks of the electrical machine were received with

[2] A tun is a cask that bulges in the middle and the meaning of the verb is associated with that of the noun.

laughter by the Royal Society. But the records in the *Journal Book* and elsewhere seem incongruous with such an occurrence. The warmth of Watson's praise, though he was an independent worker, his recommendation that Franklin's papers should be accepted, the repetition of Watson's commendation by the president when awarding Franklin the Copley medal all go to show that there was probably no more than a hesitation to accept Franklin's view of the particular paper to which Mitchell referred; and the absence of some papers from the *Transactions* may well have been due to an arrangement with Collinson, who regarded the communications which he had received as private letters. At that time the *Transactions* of the Royal Society were not printed by the society itself but privately and independently.

The many papers in the archives that refer to frictional electricity form in themselves an interesting collection, showing the keen interest felt in the phenomena by experimenters in Europe and America; and they give additional strength, if it were needed, to Franklin's great reputation.

There is an interesting letter of Franklin's which describes an experiment of his friend Kinnersley's, who was unable to give a satisfactory explanation of it. Franklin was himself perplexed at first. The experiment consisted in the "electrification of the air in a room" or even the air outside; when the air was changed the electrification did not disappear. At first Franklin thought that there might be some stationary medium which held the electrification, and allowed the air to percolate through it: but he observed that Kinnersley had put his two light bodies, by the repulsion of which the charge was observed, in a glass phial, and he came to the conclusion that the air gave some of its electrification to the glass.

Thus electricity was already, in the middle of the eighteenth century, offering a new field of experimental inquiry, and the importance of it was becoming realized. In the words of Martin Folkes, president from 1741 to 1752:

> Electricity seems to promise an inexhaustible Fund for Inquiry: and sure *Phenomena* so various and so wonderful can arise only from Causes very general and extensive, and such as must have been designed by the Almighty Author of Nature for the Production of very great Effects, and such as are of great Moment to the System of the Universe.

The numerous papers on frictional electricity form one of the most interesting sections of the archives during the eighteenth century. The society's membership did not equal in brilliance that of the centuries that preceded or followed. But there were several great subjects of consideration besides that in which Franklin made so prominent a figure. A large collection of Fahrenheit papers shows the interest taken in thermometers in the earlier part of the century. Another large collection deals with inoculation against smallpox. At the end of the century Rumford describes his beautiful and valuable experiments on heat: he is prolix of words, but he makes excellent reading. He was, of course, a pioneer in the experimental study of the nature of heat. His work is well illustrated in the society records. At the turn of the century, 18th to 19th, the chemical investigations of Humphry Davy introduced a brilliant period in British science, and these also are well recorded. The first quarter of the nineteenth century was not, however, a happy time for the society. Internal dissensions and unchecked growth of membership and the formation of societies which were formed to take over special sections of the society's work till then unrestricted, all tended to reduce the value of the records and their interest. There were denunciations of the management and laments over the decline of science. Yet one of the greatest periods of scientific discovery had already begun, with Young, Fresnel, Davy and Faraday. But now the language began to be more difficult to the uninitiated. When the phenomena of electricity, magnetism, chemistry, light came to be studied in their mutual relations, the new world in which they figured was difficult of entry. This was not only because ideas were new and could only be represented with the aid of analogues, such as current, pole, capacity and the like, but also because new terms had to be invented to provide labels for conceptions which had never entered men's minds before. What, for example, could such words as anode and cathode mean to the non-electrician? So the ordinary reader is left behind, and the language of science becomes rapidly specialized.

It is interesting to observe the care with which Faraday chose his terms. He was in the habit of consulting Whewell, the master of Trinity College, Cambridge; the correspondence is preserved in Trinity College Library and in the Royal Institution. A letter in the possession of the Royal Institution reads as follows (Whewell is replying to Faraday):

> . . . I still think *anode* and *cathode* the best terms beyond comparison for the two electrodes. The terms which you mention in your last show that you are come to the conviction that the essential thing is to express a *difference* and nothing more. This conviction is nearly correct, but I think one may say that it is very desirable in this case to express an *opposition* a contrariety, as well as a difference. The terms you suggest are objectionable in not doing this. They are also objectionable it appears to me in putting forward too ostentatiously the arbitrary nature of the difference. To talk of Alphode and Betode would give some persons the idea that you thought it absurd to pursue the philosophy of the difference of the two results, and at any rate would be thought affected

by some. Voltode and Galvanode labour no less under the disadvantage of being not only entirely, but ostentatiously arbitrary, with two additional disadvantages; first that it will be very difficult for anybody to recollect which is which; and next that I think you are not quite secure that further investigations may not point out some historical incongruity in this reference to Volts and Galvani''

. . . I am afraid of urging the claims of *anion* and *cation* though I should certainly take them if it were my business—that which goes to the *anode* and that which goes to the cathode appearing to me to be exactly what you want to say. To talk of the two as *ions* would sound a little harsh at first: it would soon be got over.

The selection of the terms anode and cathode were based on a suggestion made by Faraday. In order to obtain a description which he could remember he supposed his electrolytic trough to be placed parallel to the equator, and the current in the trough to run in the direction in which a current would have to run round the earth in order to give to the earth its observed magnetism. This implied that the current ran from east to west. It came, therefore, from the sunrise and went to the sunset, and the terms anode and cathode were taken as describing the way of the sun in the morning and in the evening.

You may be interested if I recall to you an item of history. Not long ago the council of the Royal Society decided to open some sealed letters which had been deposited with the secretaries a century ago and more. There was no apparent reason why their contents should still be kept secret. One of them was written by Faraday in 1832. It read as follows:

Certain of the results of the investigations which are embodied in the two papers entitled Experimental researches in Electricity, lately read to the Royal Society, and the views arising therefrom, in connexion with other views and experiments, lead me to believe that magnetic action is progressive and requires time; *i.e.*, that when a magnet acts upon a distant magnet or piece of iron, the influencing cause (which I may for the moment call magnetism) proceeds gradually from the magnetic bodies, and requires time for its transmission, which will probably be found to be very sensible.

I think also, that I see reason for supposing that electric induction (of tension) is also performed in a similar progressive way.

I am inclined to compare the diffusion of magnetic forces from a magnetic pole, to the vibrations upon the surface of disturbed water, or those of air in the phenomena of sound, *i.e.*, I am inclined to think the vibratory theory will apply to these phenomena, as it does to sound, and most probably to light.

By analogy I think it may possibly apply to the phenomena of induction of electricity of tension also.

Faraday had learnt the advisability of preserving evidence such as this in case he might seem to have adopted the ideas of others. It shows that Faraday's conception of electromagnetic pulses or waves occurred to him long before he published his paper on "Thoughts on Ray Vibrations" in 1846. Curiously enough, when the society's librarian was helping me to gather these few notes, a slip of paper fell out of one of the books consulted. It is in Maxwell's handwriting:

The electromagnetic Theory of L^t as prop^d by him (Faraday) in Thoughts on Ray Vibrations (Phil. Mag. 1846, May or Ex.Res.III.p.447) is the same in substance as that wh. I have begun to develope in this paper (A Dyn^l Th^y of the E^c Field. Part VI pp497–5 Ph Tr 1865) except that in 1846 there were no data to calculate the vel of propagation. J.C.M.

The passage was subsequently incorporated in Maxwell's papers.

Many groups of papers in the archives relate to work done for the government, or for national enterprise, eclipse expeditions, biological and geodetic expeditions and so on. There is an interesting bundle of Sabine papers which have not yet been published. Sabine (1788–1883) was largely responsible for magnetic surveys in various parts of the world. Not a little of it is concerned with New England. There are letters from G. P. Bond, of Cambridge, the astronomical observer of the American Academy of Arts and Sciences, discussing the magnetization of the earth; from I. M. Gillin, of the Observatory at Washington; T. D. Graham, of Baltimore; A. D. Bache, belonging to the Coast Survey, and so on. A letter from the secretary of the American Academy announces the appropriation (22 April, 1840) of $1,000 for the purchase of instruments recommended by the Royal Society.

I shall say nothing of records more recent. We are all familiar with the bold advance of modern science, and extracts from the archives relating thereto would be superfluous. Specialization continuously increases. Papers become ever more complicated, each appealing only to a fraction of the scientific world and not at all to the general reader. The change from early times is very great indeed. It is inevitable and it implies success in experiment and deduction. But its effects are serious and must be examined carefully.

These extracts show, I think, that the archives furnish a rich commentary on the history of the period during which the Royal Society has been in existence. They show too that the society has played no small part in the doings which that history records. The new spirit which gave rise to the society demanded that action should be based upon experimental research and however spasmodically the world as a whole has obeyed this new principle, however ignorant men of all kinds, rulers and ruled, have been of the working of the leaven, the change in the ordering of men's

activities has proceeded steadily and strongly. It has grown as the roots grow underground, preparing the life of the plant when the time comes for it to flourish. That time is already here, if we may judge by the extent to which natural knowledge is now used in all that men do.

We now observe the flower and the fruit that it bears. As we all know, we have reason both for satisfaction and for anxiety. We do see the happy results of a better acquaintance with nature in a greater freedom from disease, in a richer life, in new opportunities for the exercise of talent, in a wider outlook. On the other hand, the problem of the well-being of the community is still far from complete. Not long ago your American Association for the Advancement of Science met in Richmond to hear a noble address from its president. The very title of his address, "Intuition, Reason and Faith in Science," was an indication of the position from which many of our most thoughtful scientists regard the problem as it stands to-day. From our side of the water we were glad to send Sir Richard Gregory to show that we also are trying to take our bearings for a new advance. We can not stand still, of course; we must go forward, even though the way is not clear. We know the strength of science, we see that it has done great things, and are confident that its powers can be employed with greater and greater success as we give our whole minds to the problem that we have to solve. How shall we ensure the right use of natural knowledge, give full play to its beneficence and prevent its abuse? You and we and, let us hope, all associations of scientific men the world over are of one mind in this matter, and are glad of the strength that unity brings.

The very fact that we share this good-will points to the road that we must take. The good-will that is based on our mutual understanding of what we are striving for is somehow to cover the world. I have not of course the presumption to say that science is by itself to leaven the whole. There are other incentives to cooperation; first and foremost stand the binding forces of pure religion. But the cooperation of the scientists is a new leaven, though it is not the first in the field. It is our own contribution which, if we can make, we must make or we fail in our duty to the world. I assume that we accept the duty.

We can surely conclude, from what we learn in the accumulated accounts of their doings, that the learned societies have not been unmindful of this primary purpose. No doubt in the early days when men collected facts as matters of interest, the recitals to which they listened were to many of them a private benefit only. Yet there were always men of wider vision who saw also the future benefit to their country or the world in the ordering of natural knowledge. The archives of the Royal Society into which I have dipped here and there in order to provide illustrations of my argument show the continuous endeavor of a body of scientists to be of help to their fellowmen. They may not have been always conscious of such an effort; in any community you may find some who are purely selfish. But as a body of men, vivified by those who had in them most of the right spirit, they have played a great part and I believe firmly a beneficent one.

We can not but ask ourselves whether it is possible to say that such and such actions and dispositions of societies like yours and ours have been the dispensers of good, while others are to be set on the opposite side. Some results derived from science are good: some already are bad. Are these antitheses related to similar opposites in our work as scientists?

Most thinkers now agree that we are not responsible for the uses that are made of the knowledge we find. We can not control the strong passions that seize upon discoveries for selfish purposes. The work of discovery goes on and no one can stop it, not even ourselves. The constant demand for knowledge that is required for the solution of problems in health, in industry, in every human activity is so insistent that knowledge increases continuously and rapidly. And even if there were not this practical urge there would be the never-failing curiosity to know more. We must therefore accept the position; we all seek for an understanding of how to make the best of it.

I have referred already to the addresses given recently by Dr. Birkhoff and Sir Richard Gregory. They illustrate a movement which gathers strength. It is based on an anxious determination to find out how the new situation is to be gauged and treated, and in particular, what the scientist may do. There is so much inquiry to be made before an answer can be given to this general question that it would be wrong to anticipate a conclusion. We can only remind ourselves of a few obvious lines of action, which we take in the expectation that the less obvious will become clear.

There is the great question of right exposition. It may be that there are some who would even now disclaim any duty of scientific men in this respect; and certainly there were many who would have done so in the past. If, however, we suppose that natural knowledge and the power which it gives are a common possession of mankind, we ought to make sure that what is found is understood. We can not compel men to make use of science in the right way, but the chance that good use will be made is in a curious way dependent on the ease with which it is stated. If its expression is in forbidding terms, the man who sees no direct benefit from the effort of facing a difficult understanding leaves it alone. On the other hand, the man who is engaged in a fight against his fellows, whether in business or in war, grasps at any

advantage that knowledge gives him, if he becomes aware of it. And of late years such men have seen the advantage, whence comes much of our present perplexity. The world is horrified by the development of frightful engines of war. It observes too that a technical invention, based it may be on some new scientific discovery, may throw great industries out of gear and bring misery upon employers and employed. These are obvious evils, and it is not surprising that the proper desire to increase knowledge is supposed to be associated with a tendency, even a desire to make ill use of that knowledge. Also those men of good will who are acquainted with scientific aims and achievements have their own peculiar distress because they know how little is done for the general good, compared to what could be done.

Exposition, therefore, becomes one of our chief concerns. It must be mated necessarily with the understanding that appropriate education can provide. We desire that all men and especially men of good will, and especially also men of good education who are the natural leaders should be aware of what science is doing and can do. A certain surviving distrust based on past misapprehensions has to be cleared away and replaced by cooperation.

I was standing once on the platform of a little upcountry railway station in Australia, with others who had come to share the mild excitement of the arrival of the infrequent train. There was bustle when the train was ready to start, flag waving, bell ringing and cries to stand back. The engine whistled loudly, and went off by itself: the coupling with the train had been forgotten. There was a moment's pause, and then a shout of laughter while the shamefaced officials set out to repair their mistake.

There is something like that in what is taking place to-day. Scientists are so preoccupied with their business of research, naturally so, and in their researches have gone so far that the world has no clear knowledge of the positions that have been reached. We have to see to the coupling and take the world with us. It may seem ungracious to make a statement of this kind when so much is already being done to popularize scientific knowledge. Yet it is to be observed that much of the science which is absorbed by the people lies on planes of lower value. Some that is intended for popular enlightenment is of that kind which seeks to dazzle by the recital of huge numbers. We must, of course, learn how narrow is our knowledge if we limit it to the consideration of spaces of about the same magnitude as our own bodies, or of times comparable with our own length of days. But that is a lesson in humility; the mere staring at big figures is childish if there is nothing more.

There are scientific writings which tend to be mystical and need very careful reading, lest they seem to contain a meaning when in fact they do not. Some of the terms used to describe scientific observations are drawn from the general vocabulary, such as wave, vibration, ray, ether and so forth, and are defined or redefined for the specific purpose. If they are allowed to carry at the same time any unrestricted meaning that can be given to them in ordinary usage an argument which includes them gets out of control and leads to danger.

The observations of natural science, though they have now passed far beyond the range of the unaided senses, have not left the plane in which eyes and ears are accustomed guides. Neither they themselves nor any combination of them rise to a higher plane: that is reserved for conduct, which, however, must take account of them.

The understanding of science that should be general to all men is of a simpler kind. It rests on a knowledge of the elementary laws of nature, so far as we can ascertain them, and an appreciation of their continuous influence upon our lives. It leads to an awareness of the general position, though not necessarily a detailed acquaintance with it. It couples us all together in the desire to learn from nature. We enrich our own lives, and we learn how to enrich the lives of our neighbors; but the great happiness lies in the discovery that there is a world in which we can all work together for the common good, in which there is endless work to be done, and an unselfish purpose can lead us from strength to strength.

Herein lies the finest work of science. Even the relief from pain and disability, the increase both in quality and in quantity of the fruits of the earth, the betterment of all the conditions of life are not the end; there is something higher. It is the mutual service that is rendered when these things are fought for, and the happiness of mutual trust and reliance, and the last great act of virtue, that is to say the sacrifice of self. To quote from Dr. Birkhoff's address: "I would state a fundamental truth about the social level which in some sense is the highest level of all [ranking, that is to say, above four other levels which he described, mathematical, physical, biological, psychological]: the transcendent importance of love and goodwill in all human relationships is shown by their mighty beneficent effect upon the individual and upon society."

Collectively and individually scientists have done great things. Yet their achievements have value of one kind, and the spirit in which they worked has value of another kind; and the latter value is far more to be desired than the former. We may truly say of some of our greatest men of science that the world has gained more from their lives than from their discoveries, and this is so even if their influence on the world is limited to that which the world has been able to perceive. Their discoveries made

em famous, but they themselves are better known an their discoveries. Faraday's reverence for truth d unselfish devotion to its acquisition have a higher lue than the laws which he established. We gladly lmit our debt to Pasteur and to the Curies, and t the inspiration which we draw from their lives even better than the results of their work. The orld admires Franklin for his discoveries in electricy, yet it respects him more for his wisdom. I might rolong the list, but every one here can do that for imself. In brief the spirit in which knowledge is ought and the manner in which it is used are more portant, more real than knowledge itself.

The records of scientific discovery, of the developent of the fields of experiment which began three undred years ago, have shown the growing power of ience. The extent of their power is to-day a chief oncern; we must, as so many are now trying to do, ive anxious thought to its exercise. The power is ot actually in the hands of the scientist, though he is eeply interested in its future because he has been nd is the occasion of its existence. It may fairly be nferred from experience that the scientist himself will never be a tyrant. His work does not rouse in him the desire to dominate, but rather to assist. Love of accuracy, patience, perseverance, self-denial have been common qualities and necessarily so. These have a place in the general esteem, and therefore have their effect. Most of all the world respects the devotion to service that has so often been found; the warm love of their fellows which has inspired so many to give themselves and their labor without counting the return. We must hope that such a spirit will continue in ourselves, whether as individuals or as societies.

The problems of society and in particular those into which natural knowledge enters so powerfully will long demand a patient examination. But whatever may be the tactics that are developed in the end, it is certain that the satisfactory solution will be based upon moral influence. It is for us, as scientists, to supply the natural knowledge and help in its application, but that is not the complete account of what we have to do. Our effectiveness will depend, as is shown by all human history including our own limited experience, upon the devotion, wisdom and good-will which we bring to our task.

SCIENTIFIC EVENTS

THE ZOOLOGICAL SOCIETY OF LONDON

In a summary of the annual report of the Zoological Society of Great Britain, given in the London *Times*, it is reported that there was a decrease of 130,885, compared with 1937, in the number of visitors to the Zoological Park, London, last year. This is attributed mainly to the September crisis. The total number was 1,816,012. At Whipsnade there was an attendance of 523,345, a decrease of 23,073.

The number of visitors to Regent's Park was the twelfth highest in the history of the society. Admission receipts were £5,628 less than the previous year, and total income amounted to £112,957, a decrease of £12,165. Expenditure was £112,488, a decrease of £5,061, leaving an excess of income over expenditure of £469. Receipts for admission to Whipsnade decreased by £1,077. Income was £33,575, a decrease of £2,421, and expenditure was £27,568, a decrease of £738, giving an excess of income over expenditure of £6,007.

The average strength of the society's collection, excluding aquarium, reptile and insect houses, was 1,035 mammals and 1,846 birds. The animals at Regent's Park consumed 91 tons of hay, 156 tons of clover, 124 tons of horseflesh, nine tons of monkey nuts, 12 tons of bread, 244,649 bananas and 4¼ cwt. of honey.

The aquarium was visited by nearly 15 per cent. of those who entered the gardens. The visitors numbered 283,248, compared with 271,933 in 1937. The increase was largely due to the reduced charge of 6d. on Saturdays, instituted during the year.

In September, it is stated, a scheme was worked out for measures in case of war or other emergency. This involved the conversion of basements into air raid shelters and the removal of valuable books and documents and the families of the staff to Whipsnade.

THE TRANSFER OF DIFFICULT ALPINE PLANTS MADE AT WASHINGTON ARBORETUM

Although the Washington Arboretum at Seattle has been established for less than three years it is producing results that are attracting the attention of both layman and scientist. Thousands of plants have been propagated that are now being placed in permanent locations on the grounds where they will be kept under observation for developments of scientific and educational value.

A significant accomplishment has been the transfer, in one year, of alpine and subalpine plants from their natural altitudes to sea level with no loss of vigor and with no apparent change in character. Three notable instances of successful transfer were *Campanula piperi,* a miniature evergreen member of the Campanulaceae; *Lewisia tweedyi,* the largest and most beautiful of the Lewisia tribe, and *Douglasia dentata,* a rose-colored evergreen member of the Primulaceae. The domestication of these three little known but valu-

able plants will be a distinct addition to the small list of strictly alpine plants now in use, but the real significance of the accomplishment was that the successful transfer of these difficult plants from altitudes of 7,000 feet or more down to sea level without loss of time was an encouraging indication that in this far western arboretum the development of plant life can be carried to points hitherto unknown.

The Washington Arboretum is situated on the shore of a large inland salt water basin within an area governed by natural phenomena probably without parallel. This enormous inland sea is almost completely enclosed in high, storm-excluding mountain ranges and filled with warm water that flows in from the equatorial streams of the Pacific Ocean. Hygrothermograph charts show a relationship between air and soil temperatures and humidity that is particularly favorable to plant life. The variation in summer and winter atmospheric temperatures is enough to insure plant vigor and hardiness, but is neither extreme enough, nor abrupt enough to retard plant growth.

The presence of conditions unusually favorable to plant life as shown by the natural vegetation has been recognized by scientific men, such as the late Henri Correvon, Reginald Farrar and Dr. E. H. Wilson.

The accomplishments of Washington Arboretum have substantiated their belief that the further development of plants already domesticated and established should be attempted under these conditions.

With a plan of organization similar to the one used at the Arnold Arboretum and the avowed purpose of collecting all reliable information on plant life of educational or scientific value; located on a site of ample size (260 acres) within an area particularly favorable to that purpose; under the scientific supervision of Dean Hugo Winkenwerder, of the School of Forestry of the University of Washington; supported by the Washington Arboretum Foundation, Dr. E. Weldon Young, president; with the cooperation of the Board of Park Commissioners of Seattle and the United States Federal Government, this latest addition to the facilities for scientific research should become one of the leading institutions of its kind in the world.

J. B. F.

DEVELOPMENTS IN ENGINEERING AT CORNELL UNIVERSITY

RAYMOND F. HOWES, assistant to the dean of the College of Engineering of Cornell University, writes that the appointment of Dr. William Abbett Lewis, Jr., of the Westinghouse Electric and Manufacturing Company, as director of the School of Electrical Engineering at Cornell University, which took effect on February 1, completes the reorganization of the administrative staff of the College of Engineering, begun in November, 1937, with the appointment of Professor S. C. Hollister as dean. To succeed Dean Hollister as director of the School of Civil Engineering, Dr. W. Lindsay Malcolm, formerly lieutenant-colonel of Canadian Engineers, was secured from Queens University. Professor William N. Barnard, long head of the Department of Heat-Power Engineering at Cornell, was made director of the Sibley School of Mechanical Engineering; and with the establishment of the School of Chemical Engineering on July 1, 1938, Dr. F. H. Rhodes, professor of industrial chemistry in charge of the former chemical engineering curriculum, became director.

Since the new school has been added to the college and new administrative officers selected for the other three schools, the curve of enrolment has started upward once more, numerous improvements have been made in facilities for instruction and research, and plans have been announced by President Edmund E. Day and the Board of Trustees for a $6,000,000 program to strengthen the college's resources by increasing endowment for instruction and research and constructing the first two units of a proposed new physical plant. A trustee committee, of which Bancroft Gherardi, retired vice-president and chief engineer of the American Telephone and Telegraph Company, is chairman, and the new provost, H. Wallace Peters, is executive secretary, is raising funds for the project.

While waiting for tangible results from this long-range program, the college is constantly improving existing facilities. During the last few months two floors of Sibley Dome have been entirely remodeled. With the Mechanical Engineering Library moved to the second floor, the first has been used to concentrate administrative offices, making available additional classroom space in East Sibley. Faculty offices have also been remodeled in the Mechanical Laboratory buildings, and changes and additions made in equipment. The material testing laboratory has a new 200,000 lb. tension-compression machine, and is installing two smaller machines. Regrouped on a new concrete floor are other machines for tension-compression, torsion, transverse bending, impact and various other standard tests.

New apparatus has also been added to the photo-elastic laboratory, and a constant-temperature room for heat-transfer tests, humidity control and various other types of research in air-conditioning and related fields is under construction. A micromotion laboratory, with moving-picture cameras and projectors and other apparatus for time and motion studies of industrial operations, has recently been completed.

In the School of Civil Engineering, the sanitary and photo-elastic laboratories have made important additions to equipment, as has the material testing laboratory. A graduate students' shop for the construction of special apparatus needed for research

and a new computing room have been completed. The School of Electrical Engineering has also added modern equipment for demonstration and research, especially in the field of high-voltage transmission.

THE ANNUAL REPORT OF THE BROOKLYN BOTANIC GARDEN

THE twenty-eighth annual report of the Brooklyn Botanic Garden for the year 1938, just published, calls attention to the fact that during the past year citizens of Brooklyn contributed to the garden for current expenses and permanent improvements more than $54,000. This amount is 57 per cent. of the tax budget appropriation of the city for the support of the garden, and is in addition to private funds, income from endowment and other funds. The private funds budget of the garden was more than 56 per cent. of the total operating budget, the tax budget appropriation being approximately 44 per cent. The City of New York, therefore, derived more than two dollars' worth of return for every dollar appropriated to the Botanic Garden. The attendance at the garden was more than 1,628,000. The record attendance on May 1 of 56,145 was equivalent to 155 visitors every two minutes.

The report records 265 gifts of funds, plants, publications and other objects. The need of additional endowment is stressed by the director. This has become especially urgent since the income from permanent funds and contributions of private funds have fallen off so greatly since 1930, necessitating drastic reduction in the services which the garden renders to the public and to the advancement of science and education. Eighteen pages of the report are devoted to recording the results of scientific research on plant life done at the garden during 1938. These include studies in disease resistance in plants, on the iris and its diseases, on the classification of various groups of flowering plants, on variation in the ferns and studies of economic plants.

The extent to which the garden cooperates with the schools of New York City may be realized in part from the statement that during 1938 more than 150,000 pupils were assisted in their studies through material supplied by the garden, more than 925,000 packets of seed were supplied to school children and more than 24,000 pupils enjoyed plants raised in the garden and placed in schoolrooms.

Under the heading "Free Education," attention is called to the failure of the public to realize that all the so-called "free" educational and recreational privileges which they enjoy through the "free" museums, botanic gardens and other semi-public institutions of the city must be paid for by some one, and there is really no such thing as "free" education. Part of the cost is met by the taxpayers through the tax budget, and a substantial portion of it is met by private citizens who "in addition to their taxes make generous contributions for the support of our public educational institutions." It is pointed out that "it would be salutary if some way could be devised to make every one conscious of this fact who visits our museums, zoological parks and botanic gardens that are open 'free' every day in the year, and who attends their lectures and classes without payment of any fee. Such an opportunity costs money."

SYMPOSIUM ON THE CELL AND PROTOPLASM

DIRECTLY following the meeting of the Pacific Division of the American Association for the Advancement of Science at Stanford University, a symposium will be held in commemoration of the centenary of the cell and protoplasm, opening on June 30 and continuing through July 5.

Papers to be presented, one each forenoon, afternoon and evening, will recognize the comparable development of particulate concepts in both the biological and physical sciences since the beginning of the nineteenth century and will discuss, in view of this development and of its converging trends, some recent investigations in the fields represented. Accordingly both biologists and physicists have been invited to participate.

It is intended that the three papers scheduled for Wednesday, July 5, will link this symposium with the National Colloid Symposium, which convenes also at Stanford University on July 6.

The program of papers on the cell and protoplasm follows:

Friday evening, June 30. "Cell and Protoplasm Concepts: Historical Account," E. G. Conklin, Princeton University.

Saturday, July 1. "The Microdissection of Living Cells" (illustrated), Robert Chambers, New York University. "The Cell Wall and Protoplasm," L. H. Bailey, Harvard University. "Chromosomes and Cytoplasm in Protozoa," H. S. Jennings, the Johns Hopkins University.

Sunday, July 2. "Genes and Chromosomes," Richard Goldschmidt, University of California. "Cellular Differentiation and External Environment," C. M. Child, University of Chicago and Stanford University. "Cellular Differentiation and Internal Environment," R. G. Harrison, Yale University.

Monday, July 3. "Cell and Organism," C. A. Kofoid, University of California. "Chemical Aspects of Microorganisms," C. B. van Niel, Hopkins Marine Station. "Viruses," W. M. Stanley, Rockefeller Institute.

Tuesday, July 4. "Enzymes," H. Theorell, University of Stockholm. "Plant Hormones," F. W. Went, California Institute of Technology. "Vitamines," A. Szent-Györgyi, University of Szeged.

Wednesday, July 5. "Molecular Structure of Protoplasm," O. L. Sponsler, University of California at Los

Angeles. "Protoplasm and Colloids," L. V. Heilbrunn, University of Pennsylvania. "Structural Units," J. D. Bernal, University of London.

THE AMERICAN ACADEMY OF ARTS AND SCIENCES

THE annual meeting of the American Academy of Arts and Sciences was held at its house at 28 Newbury Street, Boston, on May 10. At this meeting it was voted to award the Rumford Medals to Professor George Russell Harrison, professor of physics and director of the Research Laboratory of Experimental Physics at the Massachusetts Institute of Technology, in recognition of his notable work in spectrum photometry and spectrum analysis. Professor Harrison is the thirty-ninth person to receive the Rumford Premium, which was established by a gift to the academy in 1796 from Sir Benjamin Thompson, Count Rumford. By the terms of the gift the medals are to be awarded "to the author of any important invention or useful improvement in heat or light."

The meeting was addressed by Professor August Krogh, head of the department of animal physiology of the University of Copenhagen. Dr. Krogh is a foreign honorary member of the academy and the recipient in 1920 of the Nobel prize in physiology and medicine.

Thirty-three new fellows and seven foreign honorary members were elected, the following being added to the scientific sections of the academy:

FELLOWS

Mathematical and Physical Sciences:

Bart Jan Bok, Harvard College Observatory.
Lyman James Briggs, the National Bureau of Standards.
Harry Edward Farnsworth, Brown University.
Clifford Burrough Purves, Massachusetts Institute of Technology.
C. Richard Soderberg, Massachusetts Institute of Technology.
Frank Clifford Whitmore, Pennsylvania State College.

Natural and Physiological Sciences:

Gregory Pincus, Clark University.
Arturo Rosenblueth, Harvard Medical School.
Frederick Fuller Russell, Brookline.
William Thomas Salter, Harvard Medical School.

FOREIGN HONORARY MEMBERS

Sir Aldo Castellani, London School of Tropical Medicine.
Arnaud Denjoy, professor of mathematics, University of Paris.

The officers elected for the year 1939–1940 were:

President, Harlow Shapley.
Vice-president for Class I, James Flack Norris.
Vice-president for Class II, Walter Bradford Cannon.
Vice-president for Class III, George Grafton Wilson.
Vice-president for Class IV, Arthur Stanley Pease.
Corresponding Secretary, Leigh Hoadley.
Recording Secretary, Hudson Hoagland.
Treasurer, Horace Sayford Ford.
Librarian, Hervey Woodburn Shimer.
Editor, Charles Henry Blake.

RECENT DEATHS AND MEMORIALS

DR. ALEXANDER LAMBERT, professor of clinical medicine at the Cornell University Medical College, from 1898 to 1932, died on May 9 at the age of seventy-seven years. He was a brother of Dr. Samuel W. Lambert, dean emeritus of the College of Physicians and Surgeons of Columbia University, and of Adrian V. S. Lambert, professor of clinical surgery at Columbia University.

DR. W. CRAMP, professor of engineering in the University of Birmingham, England, died on April 20 at the age of sixty-three years.

RUDOLPH BLASCHKA, German artist in glass, maker for more than fifty years of the glass flowers of the Harvard University Museum, died on May 1 at the age of eighty-two years. Mr. Blaschka was compelled to cease work on account of ill health some time ago.

A FUND is being raised at the Rensselaer Polytechnic Institute to found a William Pitt Mason fellowship in chemical engineering and a William Pitt Mason annual prize for the best senior thesis in chemistry. Dr. Frederick W. Schwartz, professor of analytical chemistry at the institute, has asked all former students of Dr. Mason to aid in establishing a fund of $17,500. Dr. Mason retired as head of the department of chemical engineering and chemistry in 1925, after he had served as a member of the faculty for fifty years.

TUESDAY, April 25, 1939, marked the hundredth anniversary of the birth of Thomas Jonathan Burrill. In commemoration of this occasion, graduate students and members of the various departments at the University of Illinois which had their origin in Professor Burrill's early leadership met with the seminar of the department of botany to listen to an address by Professor J. C. Blair, dean of the College of Agriculture and head of the department of horticulture. Dr. Burrill was at one time professor of botany, horticulture and entomology. He was professor of botany and horticulture (until 1903) and remained head of the department of botany until his retirement in 1913. Our correspondent writes: "He was known for his early work in microscopy and bacteriology, and was probably the first person in this country to introduce the use of microscopes in laboratory instruction. He is generally recognized as the first to demonstrate (in 1879) that a plant disease may be due to bacteria."

Mrs. McKinley has given the medical library of Earl Baldwin McKinley, who lost his life on the Hawaii Clipper last summer, to the Leonard Wood Memorial (American Leprosy Foundation). This gift has been accepted with deep appreciation by the Medical Advisory Board and the Board of Trustees of the foundation and is to be placed in the Culion Library at Culion, Philippine Islands. The collection will constitute the "Earl Baldwin McKinley Memorial Library." The Leonard Wood Memorial plans to keep the library active by subscribing for the various journals which are now included in it.

SCIENTIFIC NOTES AND NEWS

Sir William Bragg, who came to the United States to deliver the Pilgrim Trust Lecture before the National Academy of Sciences, returned to England on *The Washington* on May 17. The lecture is printed in the present issue of Science.

A few days after the death on January 26 of Professor Albert Sauveur, emeritus professor of metallurgy and metallography at Harvard University, the Association des Ingénieurs, Sortis de l'Ecole de Liége, where Dr. Sauveur studied before coming to America, voted to award to him the Trasenster Medal in recognition of his work in the field of metallurgy and metallography. On learning of his death the association decided to confer posthumously on Dr. Sauveur the medal and the accompanying diploma.

The E. J. Fox Medal of the Institute of British Foundrymen will be awarded to H. A. Schwartz, manager of research of the National Malleable and Steel Castings Company and professorial lecturer in metallurgy at the Case School of Applied Science, Cleveland, "for his contribution to the manufacture of malleable castings." This is the first time the medal has been awarded to any one outside of Great Britain.

It is reported in *Nature* that the Makdougall-Brisbane prize of the Royal Society of Edinburgh for 1934 to 1938 has been awarded to Professor D. M. S. Watson for his paper published in the *Transactions* of the society, entitled "On *Rhamphodopsis,* a Ptyctodont from the Middle Old Red Sandstone of Scotland," and for his many distinguished contributions to the science of vertebrate paleontology.

Dr. A. E. Kennelly, professor emeritus of electrical engineering of Harvard University and at the Massachusetts Institute of Technology, was elected on April 14 a member of the Royal Academy of Sciences of Upsala, Sweden.

Among honorary degrees to be conferred at the commencement exercises in June of the University of Wisconsin is the doctorate of engineering on Roy C. Muir, engineer and executive of the General Electric Company.

Dr. G. Grey Turner, professor of surgery at the University of London and director of the department of surgery at the British Post-Graduate Hospital and Medical School, will receive on June 21 the honorary degree of doctor of laws from the University of Glasgow.

The University of Aberdeen has conferred the doctorate of laws on Dr. James McIntosh, director of the Bland-Sutton Institute of Pathology, Middlesex Hospital, London, and on Dr. James Gray, professor of zoology at the University of Cambridge.

Dr. Carl Sumner Knopf, archeologist and dean of the School of Religion at the University of Southern California, has been elected president of the Academy of Sciences of Southern California; Dr. Howard R. Hill first vice-president; Dr. William A. Bryan second vice-president, and Dr. John A. Comstock secretary-treasurer.

Dr. Walter L. Obold, associate professor of biochemistry at the Drexel Institute of Technology, Philadelphia, has been elected chairman of the Pennsylvania Section of the American Institute of Chemists. Other officers elected for the coming year are Dr. Addison C. Angus, of the Philadelphia Clinical Laboratories, *vice-president,* and Dr. Harry C. Winter, of the Biochemical Research Foundation of the Franklin Institute, *secretary.*

Dr. Warren P. Tufts, head of the division of pomology of the College of Agriculture of the University of California at Davis, has been made chairman of the newly organized Western Section of the American Society for Horticultural Science.

National officers to serve during the triennium 1939–41 were recently elected by Phi Lambda Upsilon as follows: *President,* Dr. W. M. Sandstrom, associate professor of agricultural biochemistry at the University of Minnesota; *Vice-president,* Dr. W. T. Read, dean of the School of Chemistry at Rutgers University; *Secretary-treasurer,* Dr. T. F. Buehrer, professor of agricultural chemistry at the University of Arizona; *Editor of The Register,* Dr. L. F. Audrieth, assistant professor of inorganic chemistry at the University of Illinois.

Dr. William H. Taliaferro, dean of the Division of Biological Sciences and professor of parasitology at the University of Chicago, has been appointed to the Eliakim H. Moore distinguished service professorship.

DR. PAUL LESLIE HOOVER, of Rutgers University, has been appointed professor of electrical engineering and head of the department at the Case School of Applied Science, Cleveland. He will assume active work on July 1, when Professor Henry B. Dates, who has been a member of the faculty for thirty-four years, will retire from active service with the title of professor emeritus.

DR. CHESTER H. FORSYTH has been promoted to a full professorship of mathematics at Dartmouth College.

PROFESSOR C. P. OLIVER, of the department of zoology of the University of Minnesota, and Professor L. M. Winters, of the division of animal husbandry at University Farm, will represent the university at the seventh International Congress of Genetics to be held in Edinburgh next August.

DR. H. H. LOVE, professor of plant breeding at Cornell University, is spending the months of May and June at the Agricultural Experiment Station of the University of Puerto Rico. He has been invited by the director of the station, Dr. J. A. B. Nolla, to advise with the staff regarding research projects. Dr. Love has done similar work in Hawaii, China and several centers in the United States.

DONALD B. MACMILLAN will sail on June 24 on the schooner *Bowdoin* from Boothbay Harbor, Me., on a scientific expedition to Labrador, North Greenland and Baffin Land. Nine college students, who will work in ornithology, botany, geology and glaciology, will accompany the expedition. The *Bowdoin* will carry supplies to the MacMillan-Moravian School of forty Eskimo children at Nain, Labrador.

DR. MARGARET MEAD, assistant curator of ethnology of the American Museum of Natural History, has returned to the United States after spending three years of ethnological research in Bali and New Guinea.

RECENT visitors to the School of Tropical Medicine at Puerto Rico were Dr. James W. Jobling, of the department of pathology of the College of Physicians and Surgeons, who represented Columbia University at the annual meeting of the board on April 26, and R. G. Stone, of the Blue Hill Meteorological Observatory of Harvard University, who has been preparing for publication data for the book on the climate of Puerto Rico, left in manuscript by the late Dr. Oliver L. Fassig.

PROFESSOR PASTEUR VALLERY-RADOT, of the Paris Faculty of Medicine, has left for French Equatorial Africa and the Cameroons to study the general organization of native medical services.

SIR WILLIAM HENRY BRAGG, president of the Royal Society, London, was the guest speaker on May 15 at a luncheon given at the tenth anniversary meeting of the Acoustical Society of America, which was held in New York City. He spoke on the history of acoustics. Other speakers at the luncheon were Dr. Harvey Fletcher, of the Bell Telephone Laboratories, Professor F. A. Saunders, of Harvard University, and W. Waterfall, of the Celotex Company.

DR. AUGUST KROGH, professor of physiology at the University of Copenhagen, who has been visiting the United States, gave an address on "The Teaching of Physiology" before the American Academy of Arts and Sciences on May 10. He left for Europe on May 13.

FORMER PRESIDENT HERBERT HOOVER spoke at the meeting of the alumni of Northwestern University on May 1 on "The Future of Technology." Among other speakers were Dr. Glenn Frank, an alumnus, formerly president of the University of Wisconsin, and Dr. Carl E. Seashore, research professor of psychology at the State University of Iowa.

DR. LEWIS HILL WEED, professor of anatomy and director of the School of Medicine of the Johns Hopkins University, gave on May 17 the first lecture under the Robert J. Terry Lectureship Foundation at the Washington University School of Medicine, St. Louis. His subject was "Anatomy in the Medical Curriculum."

DR. HUGH S. TAYLOR, chairman of the department of chemistry of Princeton University, addressed on April 26 the sixteenth annual meeting of the Virginia Chapter of Sigma Xi. He spoke on the "Significance of Speed in Chemistry and Other Sciences." At this meeting seventeen new members recently elected were initiated.

DR. ROY WALDO MINER, curator of living invertebrates at the American Museum of Natural History, New York City, delivered on May 6 the annual lecture of the University of Cincinnati Chapter of Sigma Xi. The lecture was entitled "On the Bottom of a South Sea Pearl Lagoon."

THE two hundred and twenty-eighth regular meeting of the American Physical Society will be held in Princeton, New Jersey, on June 23 and 24. The preliminary arrangements for the meeting include a symposium of invited papers on uranium splitting. The two hundred and twenty-ninth meeting of the society will be held at Stanford University, California, on June 28, 29 and 30. There will be a joint meeting with the Astronomical Society of the Pacific on Thursday afternoon, which will consist of a symposium on "Continuous Absorption in Stellar Atmospheres." On Friday afternoon there will be a symposium and demonstration related to high-frequency electromagnetic waves. On Saturday afternoon a symposium on the use of x-rays in structure determination will be

held. Contributed papers will be presented in the mornings.

The seventeenth annual meeting of the American Institute of Chemists was held at the World's Fair, New York, on May 13, under the presidency of Robert J. Moore. A tour of the grounds was conducted by Dr. Gerald Wendt, director of science and education of the World's Fair.

The third international Congress for Microbiologists will be held in New York from September 2 to 9. Officers of the congress are: *President,* Dr. T. H. Rivers, member of the Rockefeller Institute for Medical Research and director of the Rockefeller Hospital; *General secretary,* Dr. M. H. Dawson, associate professor of medicine at the College of Physicians and Surgeons, Columbia University; *General treasurer,* Dr. Kenneth Goodner, associate of the Rockefeller Institute for Medical Research.

Ground was broken on May 11 for a high-voltage laboratory at the National Bureau of Standards, which will carry on studies pertaining to industry and phases of medical science. These will include studies of x-ray apparatus, measurement of electrical energy and the testing of electrical installations.

At the annual meeting of the Special Board of Trustees of the School of Tropical Medicine at San Juan, Puerto Rico, Dr. George W. Bachman, director, announced gifts to the school in the amount of $497,260, of which sum $425,000 were granted by the Puerto Rico Reconstruction Administration for the construction of a new library and a tropical physiology building, and $13,500 were appropriated by the Carnegie Corporation of New York for library development.

The Minnesota Academy of Science held its seventh annual meeting at Macalester College in St. Paul on April 22. A general program was held in the morning, and papers were presented in the Biological, Physical and Science Education Sections in the afternoon. The Junior Academy of Science presented a full program and a series of exhibits and demonstrations. Grants for research from the American Association for the Advancement of Science were made to Dr. Ralph W. Macy, of the College of St. Thomas, and to John Marr, of the University of Minnesota. In the evening, a public lecture by Dr. L. H. Powell, of the St. Paul Institute, introduced the group to the new science museum. Officers for 1939–40 include: *President,* O. T. Walter, Macalester College; *Vice-president,* A. M. Elliott, Bemidji Teachers College; *Secretary-Treasurer,* H. K. Wilson, University of Minnesota; *Councilors,* E. M. Freeman, University of Minnesota; E. T. Tufte, St. Olaf College; H. E. Essex, Mayo Clinic, and L. M. Gould, Carleton College. The 1940 meeting will be held on April 20 at the University of Minnesota.

The annual meeting of the New England Section of the American Society of Plant Physiologists opened at New Haven on May 12. Dr. H. B. Vickery, chief biochemist at the Agricultural Experiment Station, is chairman of the New England Section. The program included technical sessions on Friday afternoon and Saturday morning, and a banquet at the Hotel Garde on Friday night. A special subsection interested in blueberry culture met on Friday afternoon and a forum on teaching methods in plant physiology, arranged by Dr. C. J. Lyon, of Dartmouth College, was held on Saturday morning. After the dinner at the Hotel Garde, Professor G. R. Cowgill, of Yale University, described the experiences of a biochemist in Cuba and Panama.

The formal organization of a Soil Science Society of Florida took place at a meeting held in conjunction with the Florida State Horticultural Society at the Hollywood Beach Hotel, on April 18. Officers of the society elected are: *President,* Dr. R. V. Allison, head of the department of chemistry and soils, Agricultural Experiment Station, University of Florida, Gainesville; *Vice-president,* Dr. Michael Peech, soils chemist, Citrus Experiment Station, Lake Alfred; *Secretary-treasurer,* Richard A. Carrigan, assistant chemist, department of chemistry and soils, Agricultural Experiment Station, University of Florida. These, together with Henry C. Henricksen, Eustis, constitute the executive committee.

The Arnold Arboretum Expedition of 1939 to the Mackenzie basin planned to leave Boston about May 20. The objective for this season will be the South Nahanni River region. The South Nahanni is a tributary of the Liard River and drains the southern portion of the Mackenzie Mountain system. The Mackenzie Mountains are almost unknown botanically, and constitute one of the largest blank spots on the botanical map of Canada. The purpose of the expedition will be to make a representative collection of plants, and to study the local distribution of species and plant communities. It is expected that the results will contribute to an understanding of the major problems of plant distribution in Arctic and Subarctic America. The field party will be in charge of Dr. Hugh M. Raup, of Harvard University, who will collect mainly flowering plants and ferns. His wife, Lucy C. Raup, will collect lichens and mosses. The present journey is the eighth of a series conducted by Dr. and Mrs. Raup in the Mackenzie basin since 1926. It is supported by the Arnold Arboretum and the National Museum of Canada, and by grants from the Milton Fund of Harvard, the American Academy of Arts and Sciences, and the National Academy of Sciences. The party expects to return to Boston during the latter half of September.

THE National Advisory Cancer Council has recommended a grant of $23,000 to the University of California for the clinical investigation of cancer therapy with neutron rays, under the direction of Dr. E. O. Lawrence. It has also recommended a grant of $7,500 to the American College of Surgeons toward continuation of a study of hospitals and clinics for the determination of further needs in order to provide adequate clinical cancer service.

THE will of Dr. William Hallock Park, bacteriologist, formerly director of the Bureau of Laboratories of the New York City Department of Health, set aside his residuary estate to establish and maintain a fellowship fund for research in medicine, clinical work and bacteriological and filterable virus diseases. The fund is to continue in perpetuity and is to be known as the "William Hallock Park Research Fund." Dr. Park died on April 6. The trustees are authorized to accept gifts from other donors to the fund. The committee consists of the dean of the New York University College of Medicine, the dean of the College of Physicians and Surgeons of Columbia University, the dean of the Cornell University Medical College, Dr. Camille K. Cayley and Bela Schick. Dr. Cayley receives a bequest of $20,000 with discretionary power to use part of it for research work in medicine.

G. MATHEWS, an Australian ornithologist living in England, has presented to the Commonwealth for the National Library in Canberra what is believed to be the most valuable collection of books on Australian birds in the world. The library was shipped to Australia in April, and Mr. Matthews will visit Australia for two months in order to assist in setting up the books and arranging the catalogue.

DISCUSSION

THE LUMINESCENCE OF ADHESIVE TAPE

INTEREST in bioluminescence has led me to investigate a number of luminescent phenomena which sometimes have been vaguely referred to as triboluminescence and whose explanation does not seem to be widely understood. Most experimenters have observed the transient greenish luminescence which occurs at the point where electricians or surgeons' or "Scotch" tape is stripped from a roll. With some samples this luminescence may be so bright that it is visible with only partially dark-adapted eyes. The phenomenon can be repeated if the tape is rewound and then restripped and also appears when the sticky sides of the tape are pressed together and then separated. It occurs under cold or hot water since a film of air prevents the immediate wetting of the surface. Rubber cement (grippit) whether holding together two pieces of metal, glass, paper, Cellophane or two different materials gives luminescence when the surfaces are separated.

What is not so well known is that many substances when closely adhering to each other will also luminesce when pulled apart. Films when stripped from glass or metal will give a flash of luminescence, for example, collodion dissolved in ether-alcohol mixtures poured on a glass plate and allowed to dry; also ambroid, or rubber latex in aqueous solution such as is used in making toy rubber balloons. However, dextrin as an adhesive separated in the moist stage does not luminesce.

Collodion films are the most striking luminescent bodies. A film removed from glass can be pressed on the glass and will luminesce when removed a second time. Stroking the collodion with the fingers will also result in luminescence but not if the fingers have been moistened with water. Cellophane does not luminesce when stroked with dry fingers.

It is an old observation that mica sheets give a flash of light when split or when crumpled together. Rubber bands will also flash when snapped, although I have only observed the light in one or two instances as the stretched band returned to the short form.

It is apparent that these phenomena have a decidedly electrical flavor. A sheet of collodion stripped from glass or ebonite has a high negative charge, leaving the glass and ebonite positive. It is attracted to the glass with considerable force and sticks to the hand and other objects. The sign of the charge is easily determined by pith ball experiments.

The explanation of such luminescences appears to be this: whenever two surfaces are separated from each other the capacity diminishes and the voltage rises until a discharge takes place, exciting the surrounding gas to luminesce. It is not possible to prove that mica sheets or tire tape, surgeons' tape or Scotch tape are oppositely charged as a whole when pulled apart, but there are no doubt local positive and negative regions developed, the discharge between them giving rise to luminescence.

That a discharge does actually take place can be readily shown by stripping surgeons' tape or Scotch tape in an atmosphere of 2 to 4 cm Hg pressure of neon gas. Then the luminescence is reddish instead of yellowish. Red luminescence also occurs when two strips of mica are pulled apart or when collodion or ambroid or rubber cement is stripped from glass in a low-pressure neon atmosphere. When black tire tape is stripped in neon, the reddish luminescence is not marked. Possibly we have in this case the quenching

of the neon by some unknown volatile constituent of the tire tape, since even n-butyl phthalate, whose vapor pressure compares with that of mercury, contains something that prevents neon luminescence when excited electrically.

The phenomenon is quite similar to the well-known luminescence when mercury is shaken in an exhausted tube. If neon is present the luminescence is reddish. The light in a Torricellian vacuum at the head of a mercury column when carried from room to room was observed by Picard in 1675.

These experiments suggested study of the flashes of light observed when crystals are broken, true tribo-luminescence, characteristic of either minerals or organic compounds, as when two lumps of sugar are rubbed together. If a crystal is piezoelectric, large potential differences are built up by compression. Rochelle salt crystals, strongly piezoelectric, give an orange luminescence when shaken in a tube with 5 cm of neon but no light when shaken in a tube with air, although a flash of light appears in air when the crystal is broken with a hammer. Sugar crystals (rock candy), also piezoelectric, give orange flashes when crushed in 5 cm of neon. Indeed, a large number of substances which do not luminesce on crushing or rubbing in air give a reddish luminescence if shaken with a steel ball in a glass tube containing 5 cm neon. Such are fragments of pyrex glass, galena, Kieselgur (filtercel No. 503), $KClO_3$ crystals, KCl crystals (some samples of which are said to be tribo-luminescent in air), chitinous Cypridina shells and silk fragments. The reddish luminescence observed in shaking these materials is undoubtedly due to discharges from tribo- or piezo-electricity. However, when crystals of salicylamid, salophen and uranyl nitrate, markedly triboluminescent in air, are shaken in 5 cm neon, in addition to some orange luminescence, which represents electrical discharge in the neon, the bright greenish or colorless sparks of triboluminescence are still apparent. They are not definitely orange or reddish in color.

In triboluminescence of some crystals we therefore have the possibility of light from electrical discharge in the surrounding gas and in addition the excitation of molecules of the crystals themselves. It is noteworthy that salicylamid, salophen and uranyl nitrate are all markedly fluorescent substances whose molecules are excited by ultra-violet light. The luminescence on stripping tapes covered with rubber cement or the separation of various films from surfaces appears to be due entirely to electrical discharge in the surrounding gas.

It is a pleasure to acknowledge the assistance of Mr. Charles Butt in carrying out these experiments.

E. Newton Harvey

Princeton University

CONSUMPTION OF TEOSINTE SEED BY BIRDS IN GUATEMALA

Teosinte (*Euchlaena mexicana*), the wild relative of maize, occurs in Guatemala and Mexico often along fence-rows. Kempton and Popenoe[1] suggested birds as a possible factor in the spread of this grass. During a residence in Guatemala for the purpose of studying the maize agriculture of the Indians for the Carnegie Institution of Washington, the writer undertook observations in most of the teosinte localities of the republic with a view to determining what role, if any, birds might play in the distribution of the plant.

A visit was made to the Jutiapa region in southeastern Guatemala in the month of October, 1937. The teosinte seed proved to be unripe at that time, although in other years the month of October had marked the maturity and almost complete scattering of the seed. The prolonged rainy season of 1937 apparently delayed the ripening of the seed, which reached maturity near the end of the following month. During a second visit to Jutiapa made in this month (November), large numbers of birds were observed in the teosinte growths. Many examples were shot and stomach contents noted, whereby it was shown that several species of birds feed upon teosinte seed. A most remarkable fact brought out by these observations is that the birds do not swallow the entire rachis segments, but first remove the horny outer covering which might prove indigestible. The exact manner in which the birds accomplish the extraction of the inner grain was not observed, but local residents claim that at times one can hear the cracking of the outer shell by the birds. All the birds in whose stomachs the seed was found possess powerful beaks.

Specimens collected in the teosinte fields and sent to Washington for the collections of the U. S. National Museum were identified by Dr. Alexander Wetmore as belonging to the following species: *Passerina cyanea*, indigo bunting; *Guiraca caerulea caerulea*, eastern blue grosbeak; *Guiraca caerulea eurhyncha*, large-billed blue grosbeak; *Aimophila ruficauda*, russet-tailed ground sparrow.

The first two species are winter migrants from the United States, and the ground sparrow is native to Guatemala. The large-billed blue grosbeak, if not native to Guatemala, may be a migrant from farther north in Mexico.

Teosinte seed was found in the stomachs of all birds belonging to the first three species above listed. In the specimens of ground sparrow (*Aimophila*) the stomach contents were not identified with certainty and did not appear to be teosinte seed.

During subsequent collecting of teosinte seed in the region of Jacaltenango and San Antonio Huista in northwestern Guatemala in December of the same year,

[1] J. H. Kempton and Wilson Popenoe, *Carnegie Inst. Pub.* No. 483, p. 210, June, 1937.

similar species of birds were observed feeding upon the seed, but here no specimens were collected.

It is to be remarked that close examination of the intestines of the Jutiapa birds showed that digestion of the seed was complete in every instance and that therefore it is unlikely that these birds are a factor in the distribution of teosinte.

Raymond Stadelman

Todos Santos Cuchumatán,
Huehuetenango, Guatemala, C. A.

MULL SOIL UNDER SPRUCE

The development of the mull type of soil in spruce (-fir) woodlands has always been regarded as an unusual phenomenon. As earthworms are regarded as predominant formers of mull soil, and as earthworms prefer a limy soil, the logical place to look for mull soil under spruce would be over limestone deposits. As these occur extensively in Vermont, spruce tracts over limestones were examined in northeastern Vermont, using the *State Geologist Reports* to locate the limestone beds. A handy indicator of such deposits is the white cedar (*Thuya*). In glaciated country the mineral soil of limestone areas is so impregnated with ground limestone that the original deposits do not have to be close to the surface to influence the fauna and flora dependent on or partial to limy soil.

Throughout the region investigated, many spruce stands occur on former pastures, meadows and fields which have been subsequently abandoned and overgrown with spruce. Such agricultural land over limestone usually harbors earthworms, and these may persist in the soil for at least twenty to thirty years after the spruces have occupied the site. Such stands were not included in the investigation, which was limited to such sites as were so extreme as to have been impossible for agriculture. The following two types of sites fall under this head: (1) land too wet for plowing or pasturage, as swamps and seepage areas, (2) land too steep, as ravine sides. Such sites were invariably found to have mull soil (over limestone) except that the mull soil of the swamps was confined to a narrow strip about the edge of the swamp where the land rises from the dead level characteristic of muck swamps formed by lake filling, etc. Earthworm castings and middens were not always visible on the spruce litter, though perforations usually occurred.

The most favorable areas in Vermont were in the counties of Orleans, Caledonia, Washington and Orange. An area in northern New Hampshire (Coos County) was also found to have mull soil in similar favorable sites. Some of these sites were under large spruces and there were large tree stumps about, showing the land had been under woodland for a long period of time.

Thus it is evident that mull soil under spruce stands is not rare if sought for in situations favorable to earthworms.

Arthur Paul Jacot[1]

Northeastern Forest Experiment Station,
New Haven

GRAPTOLITES FROM HIGHGATE, VERMONT

To one who has some acquaintance with the area lying east of Lake Champlain and comprising the northwestern corner of Vermont and adjacent parts of Canada, it is not surprising to note the interest shown in this region by various geologists and advanced students. Welcome progress has been made in the interpretation of the difficult geology involved.

In view of announcements within the last three or four years of the occurrence of graptolites in certain rocks in Highgate Township, Vermont, it seems pertinent, for purpose of record, to call attention to the previous discovery and report of such fossils in Highgate.

In the summer of 1921 the writer found definite graptolite remains in slate beds in the north wall of the gorge of the Missisquoi River at Highgate Falls. Although graptolites are not infrequent in the Ordovician slates along the lake shore in Highgate, such fossils had not been reported prior to 1921 from the belt of dislocated rocks which makes up most of Highgate Township and which lies between the overthrusted younger Trenton and associated beds near the lake, and older rocks at the east in Franklin Township.

Two of the graptolites found at Highgate Falls were tentatively identified by the writer as *Dictyonema*, probably *flabelliforme,* and *Staurograptus dichotomus,* Emmons. These specimens with others were submitted to Dr. R. Ruedemann without reference to the locality at which they were found. Dr. Ruedemann thought that the specimen referred by the writer to *Dictyonema* probably belonged to that genus; but regarded the one compared with *Staurograptus* as probably a young *Dictyonema,* "flattened out in a vertical instead of a lateral direction."[1] At the time these graptolites were reported their probable significance was not appreciated.

Several years later graptolite fragments were found in the same general belt of rocks in Highgate, "about one mile northwest of Highgate Center, Vt." These fragments were referred to Dr. Ruedemann, who described them as belonging to a new species of *Dictyonema,* which he called *Dictyonema schucherti.*[2] A

[1] Dr. Jacot died on March 24.

[1] Vermont State Geologist, Thirteenth Report, 1921-22, p. 188.

[2] "The Cambrian of the Upper Mississippi Valley," Part 3, *Bull. Pub. Mus. Milwaukee,* Vol. 12, 1933.

reexamination of the material collected by the writer in 1921 at Highgate Falls has revealed a specimen (plesiotype) conforming to *D. schucherti*, but with the outlines of the thecae in general somewhat better preserved than in the holotype.

Although somewhat delayed, the recognition of this new species among the graptolite specimens found in 1921 at Highgate Falls will be of interest in correlating the slates in which it was found with other rocks of the immediate region, as well as of service in interpreting the age and structural relations among the rocks in the river gorge at the Falls.

C. E. Gordon

Massachusetts State College

SOCIETIES AND MEETINGS

JOINT SYMPOSIUM OF THE AMERICAN CHEMICAL SOCIETY, THE UNIVERSITY OF WISCONSIN AND THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A Symposium on the Kinetics of Homogeneous Gas Reactions will be held at Madison, Wis., from June 20 to 22, under the sponsorship of the Division of Physical and Inorganic Chemistry of the American Chemical Society and the University of Wisconsin, with the cooperation of Section C of the American Association for the Advancement of Science.

PROGRAM

Tuesday, June 20
9:00 a.m. to 12:00 m.
George Scatchard, *Presiding*

Everett Gorin, Walter Kauzmann, John Walter and Henry Eyring. "Reactions Involving Hydrogen and the Hydrocarbons."

Eugene P. Wigner. "Some Remarks on the Theory of Reaction Rates."

J. A. Christiansen. "On an Elementary Theory of Intramolecular Reactions."

General Discussion. "Calculation of Activation Energies and Absolute Rates."

2:00 to 5:00 p.m.
Farrington Daniels, *Presiding*

George Scatchard. "The Nature of the Critical Complex and the Effect of Changing Medium on the Rate of Reaction."

K. F. Bonhoeffer, K. H. Geib and O. Reitz. "On the Rate of Ionization in Aqueous Solution of the Carbon-Hydrogen Bond in Aliphatic Compounds."

F. O. Rice and K. F. Herzfeld. "Heats of Activation and the Theory of Free Radicals."

H. A. Taylor and M. Burton. "The Reactions between Methyl Radicals."

General Discussion. "Free Radicals." "Bond Energies."

Wednesday, June 21
9:00 a.m. to 12:00 m.
Harold C. Urey, *Presiding*

O. K. Rice and Hallock C. Campbell. "The Explosion of Ethyl Azide in the Presence of Diethyl Ether."

Guenther von Elbe and Bernard Lewis. "Mechanisms of Complex Reactions and the Association of H and O_2."

R. H. Crist and J. E. Wertz. "Kinetics of the Oxidation of Hydrogen Sensitized by Nitrogen Dioxide."

General Discussion. "Explosions."

2:00 to 5:00 p.m.
S. C. Lind, *Presiding*

G. B. Kistiakowsky and W. W. Ransom. "The Polymerization of Gaseous Butadiene."

Richard A. Ogg, Jr., and W. J. Priest. "Kinetics of the Vapor Phase Reaction of Cyclopropane with Iodine."

Robert N. Pease. "The Experimental Basis for the Theory of Quasi-Unimolecular Reactions."

Farrington Daniels and Preston L. Veltman. "The Decomposition of Ethyl Bromide and the Collision Theory of First Order Reactions."

General Discussion. "Collision Theory of Unimolecular Reactions."

Thursday, June 22
9:00 a.m. to 12:00 m.
Philip A. Leighton, *Presiding*

W. Albert Noyes, Jr., and F. C. Henriques, Jr. "Fluorescence and Photochemical Kinetics of Polyatomic Molecules in the Gas Phase."

G. K. Rollefson and D. C. Grahame. "The Effect of Temperature on the Predissociation of Photoactivated Acetaldehyde Molecules."

E. W. R. Steacie and Roger Potvin. "The Cadmium Photosensitized Reactions of Ethane."

S. C. Lind. "Chemical Activation by Gaseous Ionization."

General Discussion. "Photochemical and Ionic Reactions in Gases."

2:00 to 5:00 p.m.
George Scatchard, *Presiding*

On Thursday afternoon the University of Wisconsin will hold a general session devoted to 10-minute papers. Although technical reasons prevent the Division of Physical and Inorganic Chemistry from sharing in sponsoring this session, all those attending the symposium are invited.

This session is planned to accommodate brief reports on work completed too late for inclusion in the preprints. Any one desiring to present a short paper in this field

should submit the title and abstract of about 200 words to Farrington Daniels before June 21. The program of papers approved by the committee will be announced on June 21 at the symposium.

The symposium papers will be distributed as preprints before June 1. Together with the discussions they will be published in the *Journal of Chemical Physics*. An attempt will be made to record most of the discussions, but any one may withdraw his discussion from publication.

Chadbourne Hall, one of the university dormitories near the Chemistry Building, will be available for the symposium at rates of $1.50 per day. One floor will be reserved for families. In order to ensure accommodations, those intending to come should make reservations in advance.

Meals will be served in the cafeteria at the Memorial Union on the lake shore. Informal discussions will be continued at noon and in the evenings at the Memorial Union.

The Symposium Committee for the Division of Physical and Inorganic Chemistry is composed of E. J. Cohn, Farrington Daniels, H. Eyring, J. H. Hildebrand, L. S. Kassel, C. A. Kraus, V. K. LaMer, P. A. Leighton, S. C. Lind and G. Scatchard. The committee for the University of Wisconsin is composed of Farrington Daniels, J. O. Hirschfelder, W. E. Roseveare and J. E. Willard.

An informal dinner and launch ride are planned for the early evening on Tuesday and Wednesday.

HAROLD C. UREY,
Secretary

SPECIAL ARTICLES

THE SYNTHESIS OF A POLYSACCHARIDE FROM GLUCOSE-1-PHOSPHATE IN MUSCLE EXTRACT[1]

IT has been shown in previous papers[2,3] that dialyzed extracts of muscle, heart, liver, brain and yeast contain a phosphorylating enzyme which catalyzes the reaction

glycogen + H_3PO_4 → glucose-1-phosphate .... (1).

Glycogen is esterified with inorganic phosphate on carbon atom one of each glucose unit. The entire molecule is thereby disrupted into uniform fragments which consist of glucose-1-phosphate. Reaction (1) does not occur unless a small amount of adenylic acid (1 mM) is added to the dialyzed extracts.[4]

Another enzyme which is present in the extracts catalyzes the reaction

glucose-1- → glucose-6-phosphate .... (2).

The migration of the phosphate group is greatly accelerated by Mg^{++} or Mn^{++} ions but takes place also without their addition, so that with time all the 1-ester formed is changed to 6-ester.[5] Attempts to reverse reaction (2) have not been successful, and it became obvious that for a further study of reaction (1) the phosphorylating enzyme had to be separated from the conversion enzyme.

Adsorption with aluminium hydroxide, followed by elution with disodium phosphate, yields an enzyme solution which is rich in phosphorylase and contains relatively little of the conversion enzyme. A second adsorption and elution results in an almost complete separation of the two enzymes. These elutions, after removal of the inorganic phosphate by dialysis, are suitable for a study of reaction (1).

When natural or synthetic 1-ester and 1 mM of adenylic acid are added to these dialyzed elutions, inorganic phosphate is liberated and a polysaccharide is formed. This substance has been isolated by a method similar to that used for the preparation of glycogen from liver or muscle. Without addition of adenylic acid the enzyme remains inactive, showing that adenylic acid is necessary for reaction (1) in both directions. Inosinic or adenosinetriphosphoric acid can not be substituted for adenylic acid. Galactose-1- and mannose-1-phosphate[6] are not transformed into a polysaccharide, and their phosphate group is not split off.

The polysaccharide formed by the muscle enzyme from added 1-ester is not destroyed by heating for one hour in 20 per cent. NaOH at 100°, is insoluble in 50 per cent. alcohol in the presence of electrolytes and does not show measurable reducing power with the alkaline copper reagent of Shaffer and Somogyi. The rate of hydrolysis in 0.2 N HCl at 100° is similar to that of glycogen, and the sugar formed is glucose. When the polysaccharide is added to muscle extract with inorganic phosphate and adenylic acid, it is converted back to the 1-ester. The polysaccharide differs from glycogen by the color it gives with iodine, which is blue. Under certain conditions, particularly after prolonged incubation, the formation of a polysaccharide which gives a purplish-brown color with iodine, can be demonstrated. It is not yet possible to give an explanation for these different color re-

[1] This work was aided by a research grant from the Rockefeller Foundation.

[2] Cori and Cori, *Proc. Soc. Exp. Biol. and Med.*, 36: 119, 1937; Cori, Colowick and Cori, *Jour. Biol. Chem.*, 121: 465, 1937.

[3] Cori, Colowick and Cori, *Jour. Biol. Chem.*, 123: 375, 1938.

[4] Cori, Colowick and Cori, *Jour. Biol. Chem.*, 123: 381, 1938.

[5] Cori, Colowick and Cori, *Jour. Biol. Chem.*, 124: 543, 1938.

[6] Colowick, *Jour. Biol. Chem.*, 124: 557, 1938.

ctions with iodine. Determinations of the molecular eight of the synthetic polysaccharide may offer a lue.

Fig. 1 shows the general character of the reaction.

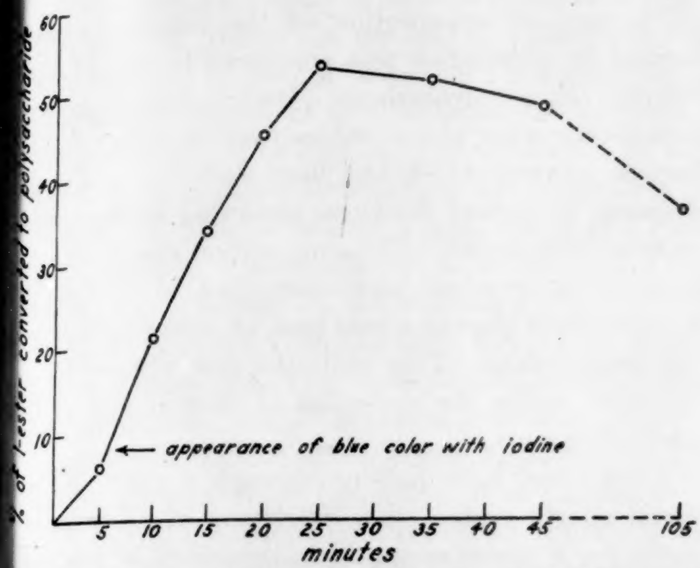

FIG. 1. The reaction mixture consisted of 2.5 cc of nzyme solution and 1.5 cc of additions; it contained 25 mM of synthetic glucose-1-phosphate and 1 mM of adenylic cid and was incubated at 30°. Aliquots of the reaction mixture were removed at the times indicated, deproteinized with trichloroacetic acid and analyzed for inorganic phosphate.

There is a definite lag, followed by a rapid attainment of an equilibrium. During the lag period the reaction mixture remains perfectly clear and the iodine reaction is negative. Often within one minute, the mixture becomes strongly opalescent, and the iodine reaction becomes positive. A liberation of inorganic phosphate occurs simultaneously. Both these points were demonstrated at a meeting of the Missouri branch of the Society for Experimental Biology and Medicine held on April 12, 1939. When the polysaccharide is determined according to Pflueger's method for glycogen, up to 91 per cent. of the calculated amount is found (calculated from the inorganic P liberated simultaneously). If some conversion enzyme is still present, as was the case in the experiment shown in Fig. 1, the reaction is gradually reversed, as shown by disappearance of inorganic phosphate between 25 and 105 minutes. This indicates that one is dealing with a reversible equilibrium.

In a recent note Kiessling[7] states that he has obtained a protein fraction from yeast juice by repeated fractionation with 0.3 saturated ammonium sulfate, which catalyzes reaction (1) in a reversible manner. This protein fraction contains the phosphorylase, the presence of which in yeast has been demonstrated before.[3] According to Kiessling the product formed from 1-ester by the yeast enzyme is a polysaccharide indistinguishable from glycogen. Kiessling's enzyme solutions remained active after prolonged dialysis against 0.3 saturated ammonium sulfate, which he interprets to mean that adenylic acid is not required. It is too early to say whether this indicates a difference between the phosphorylase in muscle and in yeast. An effect of addition of adenylic acid on the yeast phosphorylase could not be demonstrated in this laboratory.[3] It was then believed that the dialysis had not been effective in removing the nucleotide.

The interest of these findings lies in the fact that reaction (1) represents a reversible enzymatic equilibrium and that adenylic acid acts as coenzyme in both directions. Besides, the enzymatic synthesis of a high-molecular polysaccharide from a phosphorylated monosaccharide has been shown to occur *in vitro*. From the physiological point of view it seems important that glucose-1-phosphate has been shown to be the substrate for glycogen synthesis and that the same enzyme—the phosphorylase—brings about glycogen synthesis and glycogenolysis.

The difficulty experienced in obtaining glycogen synthesis in perfused organs or tissue slices is obviously due to the sensitiveness of the mechanism by which glucose is phosphorylated, a process about which nothing is known beyond the fact that oxidative energy is necessary. In yeast extract phosphorylation of glucose occurs anaerobically, linked with the oxidoreduction of cozymase. It is generally assumed that the phosphate is introduced in position 6, since only hexose-6-phosphate has been isolated. If reaction (2) should prove to be irreversible, this phosphorylation would not be the one required for glycogen synthesis.

CARL F. CORI
GERHARD SCHMIDT
GERTY T. CORI

WASHINGTON UNIVERSITY
MEDICAL SCHOOL

THE EFFECT OF ULTRA-VIOLET LIGHT ON BUILT-UP MULTILAYERS

A MULTILAYER of acid barium stearate deposited on chromium-plated steel as a built-up film to a thickness which shows interference colors changes in color after a short exposure to ultra-violet light. Optical measurements show a decrease in apparent thickness of the multilayer.

When glass having a refractive index of $n = 1.5$ is used as a base, a built-up acid barium stearate film is nearly invisible, since its refractive index is nearly equal to that of glass. Upon irradiation the multilayer becomes visible with bright interference colors having characteristics similar to those of a skeleton film.[1]

[7] Kiessling, *Naturwissenschaften*, 27: 129, 1939; see also Schäffner and Specht, *Naturwissenschaften*, 26: 494, 1938.

[1] K. B. Blodgett and I. Langmuir, *Phys. Rev.*, 51: 964, 1937.

A film made up of 48 layers, each containing equal parts of stearic acid and barium stearate (referred to as acid barium stearate), placed 25 cm from a quartz high-pressure Hg Uviarc lamp[2] operating at 300 watts, lost optical thickness equivalent to one molecular layer after 5 minutes' irradiation. Without further exposure the film continued to lose optical thickness for several hours, the final loss amounting to more than two layers. A multilayer of pure stearic acid undergoes a similar change in apparent thickness, although it is not skeletonized. Pure barium stearate shows only one twentieth of this loss under the same conditions of irradiation.

The decomposition products formed evaporate completely within ten minutes following five minutes' irradiation if the exposure is made on a film sealed within a highly evacuated quartz tube. In air or an atmosphere of Ar, N_2 or O_2 the change in thickness following irradiation continues for several hours.

By irradiating a film held at 0° C. the photochemical effect can be separated from the subsequent evaporation of the volatile constituent. When this is done the film shows no loss in thickness at the end of 20 minutes of irradiation. With no further exposure it starts to lose thickness as soon as its temperature is raised, and evaporation continues for several hours.

The photochemical effect is produced by a definite region of short-wave radiation and is related to such factors as exposure time, temperature of the film, distance from the source and intensity of the light.

Ozone seems to have little if any effect on the decomposition of the multilayers. A continuous stream of it directed for an hour against a step film produced a slight increase in optical thickness.

The radiations from a Hg arc lamp responsible for most of the photochemical decomposition were of wave-lengths between 2,300 Å and 2,700 Å. This was determined by placing a multilayer at the focal plane of a concave Wood's grating. The light after passing through a narrow slit and falling on the grating 60 cm away was focused as discrete lines on the multilayer. The effective radiation produced visible effects on the multilayer, which after measurement and comparison with the calibrated output of a similar lamp[2] directly established the wave-length region responsible for most of the photochemical decomposition. Twenty-three lines (ranging from 1,949 Å to 3,983 Å) could be seen on the film following six hours of irradiation.

Light of shorter wave-lengths also decomposes acid barium stearate multilayers. A plate bearing a multilayer was sealed in a hot cathode, low-pressure discharge tube and exposed in successive runs to the radiation from Xe, Kr, Ar, Ne and He. The optical loss following each exposure was of the same magnitude. The discharge in 2,000 microns of helium decreased the optical thickness by 16 per cent. in 2 minutes of irradiation. The helium discharge gives a resonant line at 584 Å.

The rate of evaporation of the volatile products formed by irradiation was compared to that of pure straight chain hydrocarbons. Decane, tetradecane and hexadecane were placed successively in a step film of barium stearate which had been skeletonized and the decrease in optical thickness measured as the hydrocarbons evaporated. The evaporation rate of the decomposition product when compared to that of the hydrocarbons showed a rate such as would be expected for heptadecane. This indicates that ultra-violet irradiation splits the molecules of stearic acid at the carboxyl group.

Ultra-violet light passing through a sheet of clear fused quartz coated with 700 layers of acid stearate produces a decrease in thickness which is less than when the light passes through uncoated quartz. This difference measures the absorption of the effective radiation by the acid stearate film. A comparison shows that the absorption due to the 700-layer film reduces the effective radiation by 13 per cent. This indicates an absorption coefficient for the film of 2×10^{-4} per layer.

A similar value is obtained by passing part of the light through a film and observing the reduction in brightness of lines on a fluorescent screen representing radiations from the Hg lamp in the 2,500 Å region. The light was separated into discrete lines by the Wood's grating and focused on a fluorescent screen at the focal plane. A 1,000-layer film showed an absorption per layer of 8×10^{-4} in the region of 1,800 Å which decreased to about 5×10^{-4} at 1,970 Å and 2×10^{-4} at 2,537 Å. At wave-lengths longer than 2,652 Å hardly any absorption was observed.

Irradiation by the Hg lamp of an acid stearate multilayer immersed in distilled water showed a loss after withdrawal of the same order as when irradiated in air. Very little of the decomposition product diffused into the water except after irradiation for ten minutes or more. With films made up of the shorter chain fatty acids, however, containing 14, 15, 16 or 17 carbon atoms the film after a five-minute exposure at 25 cm is partially skeletonized before removal from the water and is found to be strongly hydrophobic when withdrawn.

A paper describing further details of this work will be published in the near future.

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[2] W. E. Forsythe, B. T. Barnes and M. A. Easley, *Jour. Optical Society of America*, 24: 7, 1934.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR ESTIMATING THE DEGREE OF MINERALIZATION OF BONES FROM TRACINGS OF ROENTGENOGRAMS[1]

FOR an adequate study of skeletal status as a part of a program of research in the field of human nutrition, it is desirable to have a technique for measuring the comparative degrees of mineralization of the bones of living subjects. For this purpose, Sanders,[2] in 1935, began to use a photometric apparatus in which a ray of light was directed through a certain area of a roentgenogram onto a photronic cell in circuit with a voltmeter; the deflection of the voltmeter was compared with that obtained when the light was passed through each of a series of steps of a density ladder on the same roentgenogram. Stein[3] reported use of a photronic apparatus in 1937 and suggested employing density ladders made of ivory for comparative purposes.

The use of a beam of light through a stationary film presents the difficulty of locating comparable bone areas in the roentgenograms of different subjects. To obviate this difficulty, the authors have rebuilt a Type B Moll recording micro-photometer, designed originally for making tracings of spectra, so that it can be used for obtaining tracings from one fixed landmark to another on a roentgenogram. The apparatus as it is now in operation is shown in Fig. 1. The modifica-

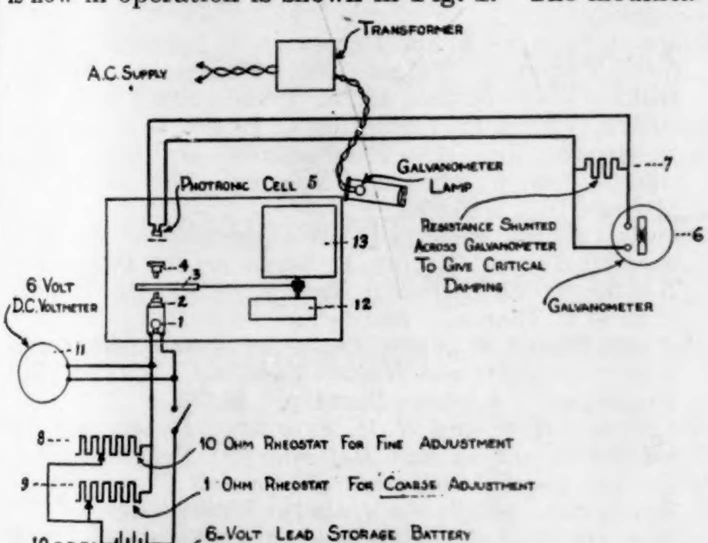

FIG. 1

tion of the original apparatus has consisted in substituting a photronic cell for the thermopile originally in the instrument, to obtain greater sensitivity and quicker response; in introducing a means of regulating the current through the light source; in providing for the continuous recharging of a storage battery in the circuit of the light source; and in introducing resistance into the galvanometer circuit sufficient to give critical damping.

In the rebuilt instrument, the light source (1) sends a beam of light through an objective (2) upon the film, which is fixed to the plate-holder (3). The light transmitted passes through a second objective (4) upon a Weston photronic cell (5). The photronic cell is connected with a galvanometer (6) (No. 1136 accompanying microphotometer No. 303, made by Kipp and Zonen, Delft, Holland) in a circuit in which resistance is shunted across the galvanometer to give critical damping (7).

The light source is maintained at constant voltage with a 10-ohm (8) and a 1-ohm (9) resistance in parallel with a 6-volt storage battery (10) in the light circuits, the former resistance for fine and the latter for coarse adjustment. A 6-volt D.C. voltmeter (11) in this circuit permits the voltage to be read. The storage battery is continuously recharged by means of a Retox type trickle charger with a capacity of about one ohm.

In making a tracing, the plate-holder is moved through the stationary beam of light by a spring motor (12), the speed of which is regulated by a magnetic damper. A cylindrical housing (13) encases a drum on which 12×40 cm. bromide photographic paper is mounted. A slot in the housing permits a beam of light from the mirror of the galvanometer in the photronic cell circuit to shine upon the photographic paper. The cylinder of the drum around which the photographic paper is secured is rotated by the same spring motor as that which moves the plate-holder; both the plate-holder and the circumference of the drum travel at the same rate.

The instrument as described is being used to make tracings of roentgenograms of both bones and teeth. By measuring with a planimeter the area between a tracing and a base or zero line, and recording the area per unit length of base line in comparison with the area between the tracing of a density ladder and the same length of base line, densities of similar sections of certain bones or teeth of two or more individuals may be compared, comparative densities of different sections of the same bone or of the same tooth may be found, and density values of bones or of teeth in terms of units of a density ladder of known mineral composition may be calculated.

We are indebted to Ernest Axman, instructor in electrical engineering, for invaluable help in adapting the Moll micro-photometer to the purpose in hand.

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[1] Authorized for publication on October 20, 1938, as Paper Number 859 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Authorized August 25, 1938, as Paper Number 3 of the Human Nutrition Series, Division of Home Economics Research, the Pennsylvania State College.

[2] A. Pauline Sanders, Ph.D. Dissertation, the Pennsylvania State College, 1937.

[3] I. Stein, *Am. Jour. Roentgenology and Radium Therapy*, 37: 678–682, 1937.

A THERMOREGULATOR AND RELAY ASSEMBLY[1]

STUDIES on longevity in *Drosophila melanogaster* necessitated the construction of an incubator[2] having a minimum temperature variation. For this reason, it was necessary to construct a temperature control assembly capable of functioning for several months without attention.

Fig. 1 shows the wiring of the incubator. The relay[3]

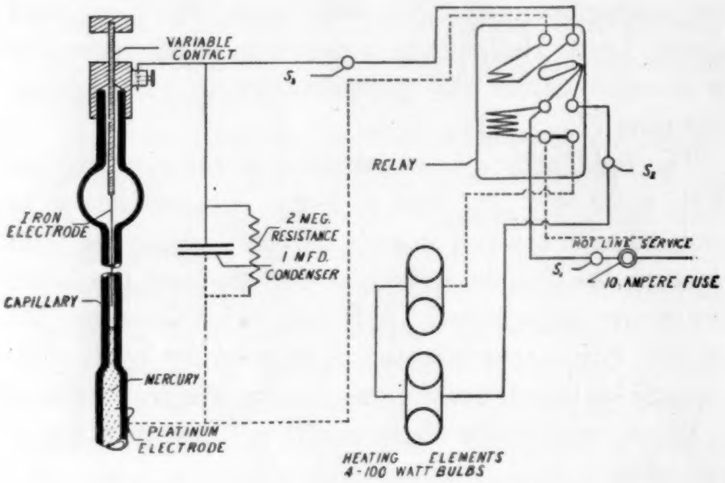

FIG. 1

employed was of the repulsion-transformer type having a "Mercoid" contact. In this relay the "Mercoid" element was reversed so that the load line contact would be broken when the pilot circuit was completed by the thermoregulator. The reversal was accomplished by removing the bottom adjusting screw and turning the contact element in its mounting.

By bridging the contact points of the thermoregulator with a one microfarad condenser, it was found possible to eliminate much of the spark caused by the "make" of the pilot circuit. It was found, however, that the charge stored on the condenser caused a fairly heavy spark on the "break" of the pilot circuit. A two megohm resistance was inserted as a shunt to dissipate the energy on the condenser. The resistance was high enough not to interfere with the storing of the charge on the condenser, but it allowed the charge to leak off during the time interval between the storing of the charge and the breaking of the contact. The heating elements were put in series, two-by-two, as recommended by Bridges. It was also thought best to protect the complete assembly through a 10-ampere fuse.

The thermoregulator first used was similar to that employed by Bridges. It was found, however, that a film was formed on the inner surface of the capillary after about one week of continuous operation. This threw out of adjustment the setting of the thermoregulator by shorting the regular contact points. To prevent the film formation, 95 per cent. ethyl alcohol, as recommended by Powsner,[4] was substituted for the toluene. This substitution aided, but after a time the film formed again. Analysis showed the film to be an amalgam of the silver from the variable contact. Since iron oxide does not form an amalgam, an iron wire was substituted for the silver electrode.

The temperature was checked every twelve hours during a continuous run of three months, and was found to vary less than $\pm 0.05°$ C. At the end of the experiment the thermoregulator was removed and the capillary examined. The only mark on the capillary was a faint black ring just above the contact end of the electrode.

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[1] I am indebted to Mr. Edwin L. Cordes, of the Marquette Physics Department, for helpful suggestions.

[2] C. B. Bridges, *Amer. Nat.*, 66: 250–265, 1932.

[3] The relay is manufactured by The Mercoid Corporation, Chicago, Illinois. The type number is V2–3A.

[4] L. Powsner, *Physiol. Zool.*, 8: 475, 1935.

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